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Micro-switches are one of the most promising field of MNT for commercial applications. The high-reliability level required for further integration of these technologies in complex systems is currently a challenging issue. Indeed, the TRL level of these devices hardly managed to increase in the past few years. Particularly, studying the behaviour of the electrical microcontact remains difficult due to small size at stakes. One of the main failures occurring when aging the devices is the increase of the electrical contact resistance. The key issue is the electromechanical behaviour of the materials used at the contact interface when the current is flowing through the contact asperities. Indeed metal contacting switches have a large and complex set of failure mechanisms driven by the current level, which depend of several mechanical and operating parameters.

From several years, we have developed a new set-up for the characterization of contact materials used in micro- switches. This approach is based on the coupling of a commercial nanoindenter with electrical measurements on adapted specimen. The diamond tip is considered as a mechanical actuator, which applies a punctual load on the free-standing electrode. Previous works showed the relevance of such an approach to simulated a distributed pressure actuation [1]. Thus, this paper reports first results obtained on several pairs of contact materials.

Works on FEM structural-contact analysis were reported at Memswave 2009 where temperature was studied at the contact interface [2]. Fortini presented a nanoscale comparison of Au and Ru contact behaviour using molecular dynamics simulation [3]. In the field of experiment, previous researchers have published data using nanoindenter testing [4], piezo actuator [5] and atomic force microscope (AFM) [6] to investigate the behaviour of Au and Au-Ni alloys as contact materials by mechanical actuation with increasing force. To our knowledge, the micro-scale heating effects on contact material are not fully understood. However these phenomena are key issue for the designers to understand the capability of the contact to sustain the current before reaching critical temperature values for the used material [2]. The analysis of the impact at low to medium power level on Au, Ru and Au/Ru based RF MEMS contacts differs from previous works as the contact temperature study is based on the experimental results. An environmental chamber is used in order to control temperature and humidity.

Dedicated validation tests and FEM modelling are presented to assess this methodology. The contact response is analyzed for 5 µm² square bumps under electromechanical stress. Dedicated test structures have been designed and successfully fabricated by LETI. These are metallic micro bridges suspended over metallic lines. Both are coated either with gold or with ruthenium. A particular attention is paid to avoid any parasitic resistance measurement thanks to a cross-rods design.

The data obtained provides a better understanding of micro-contact behaviour related to the impact of current at low- to medium-power levels. The stability of the contact resistance, when the contact force increases, is studied for contact pairs of soft material (Au/Au contact), harder material (Ru/Ru contact) and mixed configuration (Au/Ru contact). The super-temperature of the contacts have been calculated and compared to the theoretical values of softening temperatures for each material. It can be shown that this temperature can be reached for gold and ruthenium material, with different levels of current intensity. However, no softening behaviour has been highlighted for mixed contact. An enhanced stability of the bimetallic contact Au/Ru was demonstrated considering sensitivity to power increase, related to creep effects and topological modifications of the contact surfaces. These results are discussed in a theoretical way by considering the temperature distribution around the hottest niveau-surface at the contact interface. Consequently an enhanced reliability can be expected for contacts made with two different materials.

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